FINNISH PINE IS AN EXCELLENT SENSOR OF ENVIRONMENTAL CHANGES

Professor Kari Mielikäinen
Finnish Forest Research Institute
Phone: +358 50 391 2615
E-mail: kari.mielikainen@metla.fi

METLA

Nordic conifers are the most intelligent instruments for detecting changes in their environment. They measure all changes in their neighborhood (air, soil, competition, insects etc.) and store the information in their annual rings. The information can be extracted and interpreted based on ring width, wood density, cell structure and chemical content (isotopes of carbon, hydrogen, oxygen etc.) of the wood material. If fallen trees are covered by lake or soil sediments, they can store the information for thousands of years and reveal it to us. With a method called cross-dating, tree-ring chronologies can be built at annual resolution.

The Finnish chronology for Scots pine (*Pinus sylvestris*), dating back more than 7640 years is the longest conifer chronology in Eurasia. Excellent environmental signal makes it very valuable for analyzing past climatic changes. I will give two examples:

Forest decline

In the 1980´s a term called "Waldsterben" (forest decline) spread all over the world. It was based on atmospheric measurements and ocular estimation of tree crowns. Estimation of crown condition in whole Europe revealed that in many regions the defoliation of trees had been increasing several years in succession. Public media and many scientists made a connection between air pollution and defoliation and warned that large areas of forests will die in ten years.

A couple of Finnish and German forest scientists did not share the opinion without asking the opinion of trees. A project

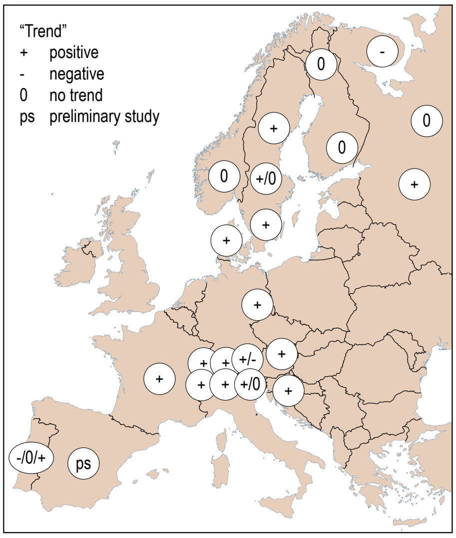

Figure 1. Growth trends in European forests in the 20th century (trees and forests growing outside forest management).

(Spiecker, H., Köhl, M., Mielikäinen, K. & Skovsgaard, J.P. (eds.) 1996. Growth trends of European forests. Springer-Verlag, Heidelberg-Berlin. EFI Research Report 5. 372 s.)

A method in dendrochronology, called cross-dating, makes it possible to build tree-ring chronologies that are thousands of years long.

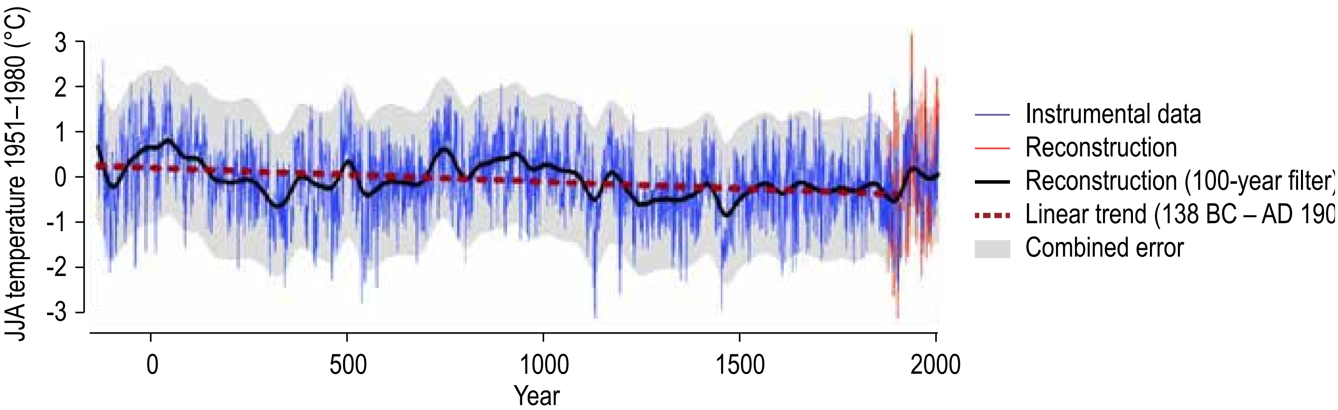

Figure 2. The estimated cooling of Finnish Lapland caused by changing tilt angle of the globe.

(Esper, J., Frank, D.C., Timonen, M., Zorita, E., Wilson, R.J.S., Luterbacher, J., Holzkämper, S., Fischer, N., Wagner, S., Nievergelt, D., Verstege, A. & Büntgen, U. 2012. Orbital forcing of tree-ring data. Nature Climate Change 2012(2): 862–866.)

consisting of 45 individual reports revealed that forests were not dying. On the contrary, Central-European forests had been accelerating their growth for more than a century. In the North no increase was found in trees growing outside forest management in nature reserves. (Fig. 1)

The conclusion was that Nitrogen deposition (25–40 kg/ha/year) coming from agriculture and traffic had fertilized forests in Central-Europe and made them grow faster. The doubling of forest growth in Finland and Sweden was thus caused by forest management, especially by the higher density and younger age of forests and drainage of peatlands.

The increasing defoliation of trees in the 1980's had natural origin outside the neighborhood of the biggest polluters. Drought, increasing age of trees, insects, mountains and impact of the ocean were the main drivers behind the variation of crown density. Air pollution, especially the content of SO_2 had no correlation with defoliation on large areas.

Climate change

In the 2000´s Nordic pines are again in the focus when solving the problems of climate change. The long chronology can tell us stories about past climate changes during the Holocene (after the latest ice age). It will also reveal some of the processes behind the changes and give information for regional forecasts. Scientific reports using our long chronology have given following answers:

1. The tilt angle of the globe is turning the Northern hemisphere out from the Sun. This can be seen in the slow cooling of the climate in Finnish Lapland (0,6 degrees Celsius in 2000 years). In addition to this trend, variation of plus/minus one degree between 30-year periods has been detected. The Roman and the Medieval warm periods two and one thousand years ago have been clearly warmer and the Little ice age, ending at the end of the 19th century, colder than the 20th century. (Fig. 2)

2. The comparison of the estimated solar activity (Sami Solanki, based on the amount of the radioactive carbon isotope in tree rings) and summer temperatures in Finnish Lapland show the cyclic behavior of Solar activity which can explain most big changes in past climates. It can also explain the warming of the 20th century after the ending of the Little ice age. (Fig. 3)

3. The comparison of bottom sediments of the Atlantic Ocean and summer temperatures in Lapland show the importance of changing activity of the Gulf Stream in the climate of Northern Finland. The changes have "solar origin" and they can cause long-term changes in our climate also in the future. (Fig. 4)

Conclusion: Do not make forecasts for forests without asking the trees!

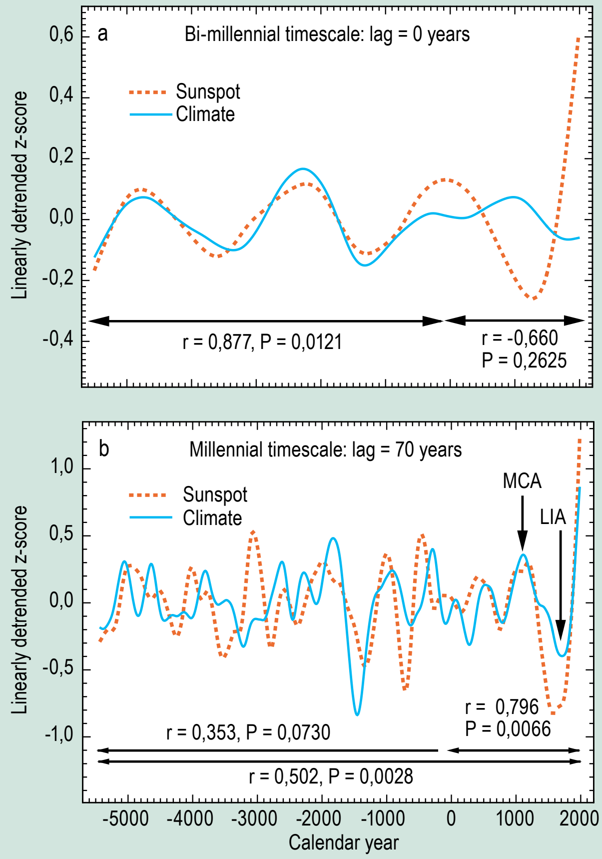

Figure 3. Sunspot-climate associations. Visual and statistical (Pearson correlation, r) comparison of the bimillennial (A) and millennial (B) components of sunspot and temperature reconstructions over the mid (this study, 5500–1 BCE) and late (this study, 1–1990 CE) Holocene. Intervals of Medieval Climate Anomaly (MCA) and Little Ice Age (LIA) are shown by downward arrows.

(Helama, S., Mielikäinen, K., Timonen, M. & Eronen, M. 2010. Sub-Milankovitch solar forcing of past climates: Mid and late Holocene perspectives. Geological Society of America Bulletin 122: 1981–1988.)

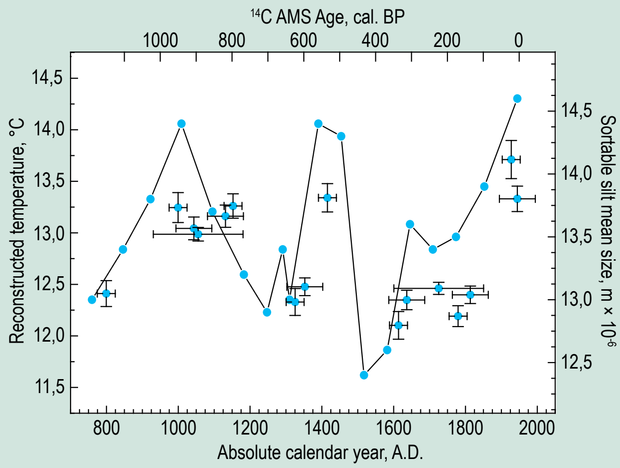

Figure 4. Reconstructed temperature variability indicated by anomalously positive and negative temperature intervals presented with estimated changes in the speed of deep ocean flow (Iceland–Scotland Overflow Water) (continuous line). Shorter line segments show warm and cold periods of 30, 100 and 250 years. The warmest 250 years in 931–1180 and the coldest 1601–1850.

(Helama, S., Timonen, M., Holopainen, J., Ogurtsov, M.G., Mielikäinen, K., Eronen, M., Lindholm, M. & Meriläinen, J. 2009. Summer temperature variations in Lapland during the Medieval Warm Period and the Little Ice Age relative to natural instability of thermohaline circulation on multi-decadal and multi-centennial scales. Journal of Quaternary Science 24(5): 450–456.)

Old trees may preserve undecayed for thousands of years in ice cold and muddy-bottomed lakes.

Defoliation, the loss of needles or leaves, is an indicator of the general condition of trees. Undefoliated spruce (left), defoliated spruce (right).

You can download photos of this article. All photos are taken by Metla/Erkki Oksanen.

http://www.metla.fi/tmp/x21-1371468011-_Q4F3234_eo1006.jpg
http://www.metla.fi/tmp/x21-1371468020-_Q4F3238_eo1006.jpg
http://www.metla.fi/tmp/x21-1371468029-_Q4F3291_eo1006.jpg
http://www.metla.fi/tmp/x21-1371468038-_Q4F3392_eo1006.jpg
http://www.metla.fi/tmp/x21-1371468047-811_12556.jpg
http://www.metla.fi/tmp/x21-1371468053-811_12560.jpg
http://www.metla.fi/tmp/x21-1371468058-Muinainen_metsanrajamanty.jpg
http://www.metla.fi/tmp/x21-1371468064-SukellusKaamanen_019.jpg